

INFLUENCE OF EXCITATION VOLTAGE OVER METROLOGICAL PERFORMANCE OF FORCE TRANSDUCERS

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Abstract: The present study discusses the effect of excitation voltage of the digital indicator over the metrological performance of the force transducers. The force transducers of 1 kN, 2 kN and 5 kN nominal capacity and having relative repeatability error better than $\pm 0.002\%$ have been calibrated on the basis of calibration procedure based on ISO 376-2004. The relative deviations due to repeatability and reproducibility error have been computed for the force transducers and results have been reported.

Keywords: force transducer, excitation voltage, ISO 376-2004, metrological performance.

1. INTRODUCTION

Force transducers have been widely used over the years for various engineering applications. Force transducers play a vital role in maintaining the traceability from force standard machines to force calibration machines as well as verification of material testing machines and serve as force transfer standards. A high resolution digital indicator is used for taking observations. The digital indicators may display the output in response to the force applied to the force transducers in form of mV/V, N/kN or divisions. Modern digital indicators used along with force transducers have various functions and options like different excitation voltage, scales etc. Though a lot of research has been done on various issues related to digital indicators, but the investigations about the influence of excitation of over metrological performance of force transducers are hardly found. The present study aims to discuss the various aspect related to the excitation voltage and its affect over the performance of precise force transducers [1].

In the present study, the force transducers of 1 kN, 2 kN and 5 kN nominal capacity. The force transducers are found to have stable observations over the years and have relative repeatability error upto $\pm 0.002\%$. A high resolution digital indicator having resolution as fine as 0.000001 mV/V has been selected for taking observations of the force transducers. The digital indicator has the options to have excitation voltage as variable as 2.5 V, 5 V or 10 V. The force transducers have been calibrated according the calibration procedure based on ISO 376. The procedure for calibration has already been discussed earlier somewhere else. The relative deviations due to repeatability error and reproducibility error have been computed at different excitation voltage and results have been reported here [2-4].

2. EXPERIMENTAL INVESTIGATIONS

The force transducers have been calibrated according to ISO 376. The procedure for calibration has already been discussed. 50 kN Dead Weight Force Machine has been used for calibration of force transducers, which already has been discussed earlier [5]. The force transducers have been calibrated for different excitation voltage like 2.5 V, 5.0 V and 10.0 V. The same calibration procedure has been adopted for different excitation voltage and results have been tabulated. The results have been reported in form of different plots (figure 1 - 9).

The calibration procedure is as follow:

- The digital indicator is switched on for 30 minutes. The no load output is noted and the calibration signal is noted.
- Before the application of the calibration forces, the force transfer standard is preloaded thrice to its maximum capacity and kept at full load for 90 seconds.
- The calibration of the force transfer standard has been done in compression mode.
- The calibration is carried out by applying two series of calibration forces in ascending order from 10 % to 100 % in steps of 10 % at initial position, considered 0° (series 1 & 2).
- Two series of calibration forces have been applied at rotation positions 120° and 240° (series 3 & 4).
- The force transfer standard is subjected to the full load once for about 90 seconds each time before starting the calibration to the new position.
- Between the loadings, readings corresponding to no load after waiting at least 30 seconds for the return to zero are noted.

$$\begin{aligned} & \text{Relative Repeatability Error (\%)} \\ & = 100x\left(\frac{\max(x1;x2) - \min(x1;x2)}{\text{mean}(x1;x2)}\right) \quad (1) \end{aligned}$$

where, x1 and x2 stands for series 1 and 2 at 0° .

$$\begin{aligned} & \text{Relative Reproducibility Error (\%)} \\ & = 100x\left(\frac{(\max(x1;x3;x4) - \min(x1;x3;x4))}{\text{mean}(x1;x3;x4)}\right) \quad (2) \end{aligned}$$

where, x3 and x4 stands for series 3 and 4 at 120° and 240° respectively.

3. RESULTS AND DISCUSSIONS

The metrological performance of the force transducers has been evaluated for the different excitation voltages as mentioned above. The results have been segregated in form of 3 plots as shown below:

- (a) Deviation from mean value (figure 1- 3)
- (b) Relative repeatability error (figure 4 - 6)
- (c) Relative reproducibility error (figure 7 - 9)

It has been found that there are variations in relative deviations due to repeatability and reproducibility error of the force transducers for different excitation voltage. Beside it, the nominal output (average values of the force transducer) for the given forces also varies for different excitation voltages.

It has been clear from the plots the there is significant variations in the average value of force transducers at different excitation voltages as seen in figure 1 - 3. It has been seen that the average value of the force transducers keep on decreasing as excitation voltage increases from 2.5 V to 10 V. There are no much significant variations found in relative repeatability error and reproducibility error.

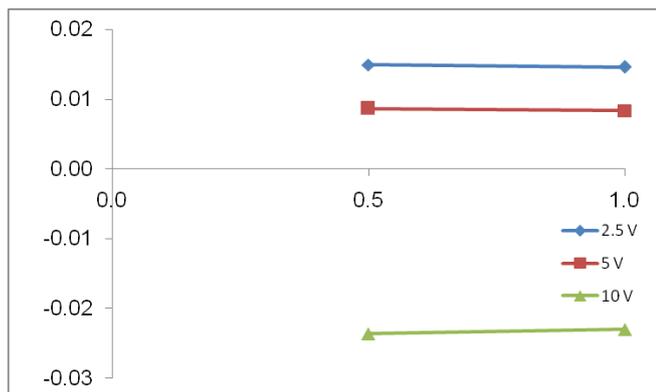


Figure 1 Deviation of Mean Values at Different Excitation Voltage for 1 kN Force Transducer

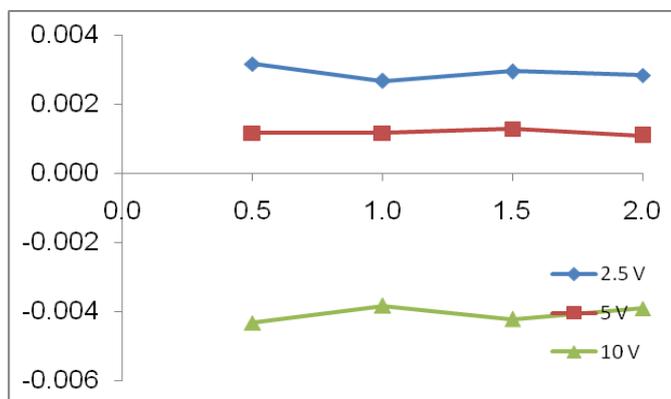


Figure 2 Deviation of Mean Values at Different Excitation Voltage for 2 kN Force Transducer

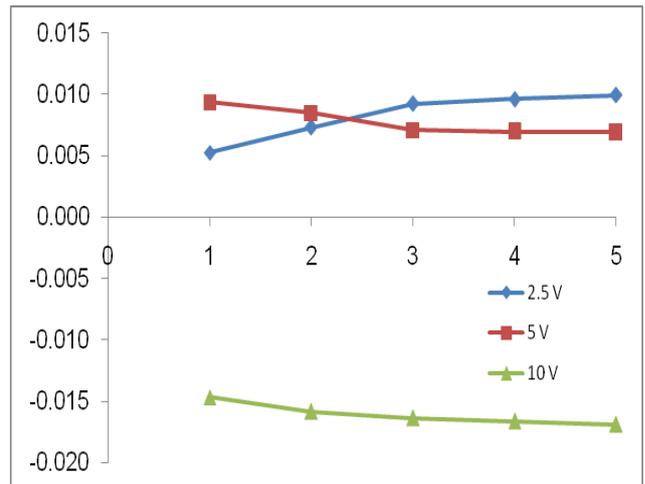


Figure 3 Deviation of Mean Values at Different Excitation Voltage for 5 kN Force

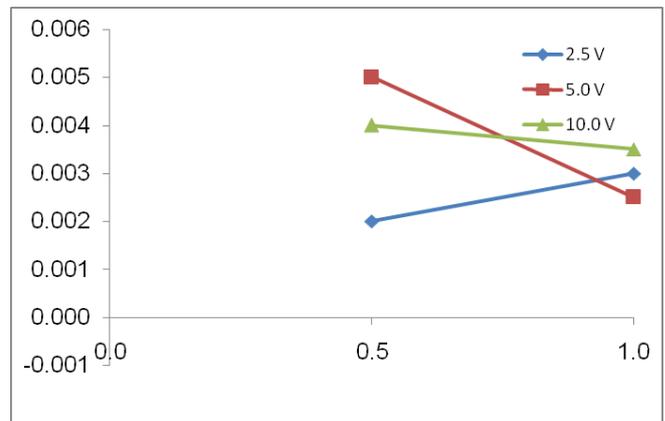


Figure 4 Relative Repeatability Error at Different Excitation Voltage for 1 kN Force

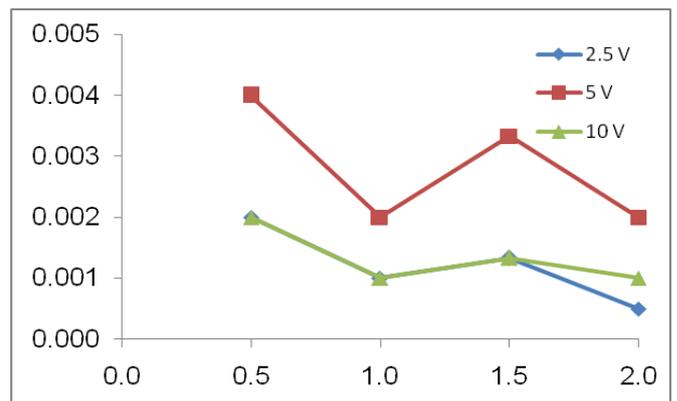


Figure 5 Relative Repeatability Error at Different Excitation Voltage for 2 kN Force Transducer

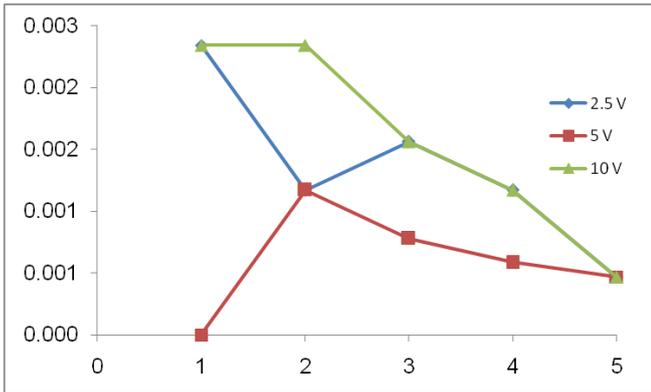


Figure 6 Relative Repeatability Error at Different Excitation Voltage for 5 kN Force Transducer

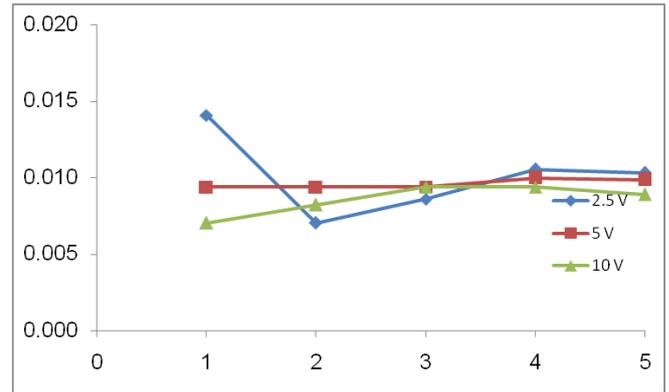


Figure 9 Relative Reproducibility Error at Different Excitation Voltage for 5 kN Force

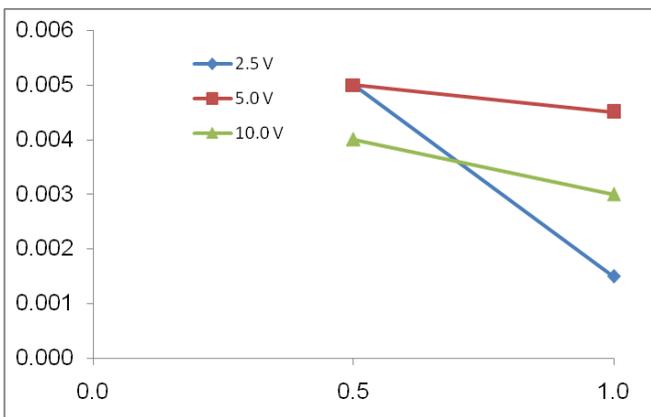


Figure 7 Relative Reproducibility Error at Different Excitation Voltage for 1 kN Force Transducer

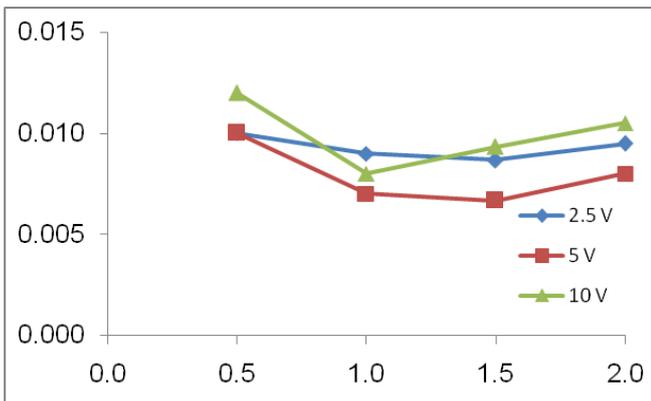


Figure 8 Relative Reproducibility Error at Different Excitation Voltage for 2 kN Force Transducer

4. CONCLUSIONS

The variations observed for the force transducer are upto 0.003 % and 0.005 % for relative deviation due to repeatability error and reproducibility error respectively. Though the variations observed due relative repeatability error and relative reproducibility error are not much, but the more variations are observed in the average values of the force transducers and it is indicated by the study that the average value keep on decreasing with increased excitation voltage and if the values at 2.5 V and 10 V excitation voltages are compared, the variations could be upto 0.04 %. Hence, this study aims for bringing out the in-depth investigations of the issues raised.

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6. REFERENCES

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